STUDIES ON SUCTORIA WITH SPECIAL REFERENCE TO SOLENOPHRYA MICRASTER PENARD 1914

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ROBERT WILLIAM HULL

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AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY
IN THE GRADUATE COLLEGE OF THE
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STUDIES ON SUCTORIA WITH SPECIAL REFERENCE TO SOLENOPHRYA MICRASTER PENARD 1914

Solenophrya micraster, originally collected from a strip mine pond some 25 miles east of the University of Illinois in November 1948, and maintained in culture in the laboratory of Prof. R. R. Kudo, Department of Zoology, University of Illinois, were established in clone cultures. From these homogeneous populations detailed studies on the morphology and life cycle of **S. micraster** were made, since no species of this genus had received such attention during the entire 93 years of the existence of genus **Solenophrya** as a taxonomic entity.

On the basis of the morphology established by these studies, the following emended specific diagnosis of **S. micraster** was proposed:

Solenophrya micraster

Lorica thin and membranous, translucent, compressed vertically, rounded pentagonal in apical outline, smoothly hemispherical with flattened convex upper surface in lateral outline. Apical face marked by five rays running from a common center to each angle of the pentagonal outline, each ray opened distally into an elliptical orifice (2 to 8 micra long by 1 to 6 micra wide) for the exit of five fascicles of rectilinear, capitate tentacles. No evidence of a peduncle or stalk basally, the smooth, hemispherical basal surface attaching directly to the substrate. Cytoplasmic body filling approximately two thirds of the lorica cavity in unfed individuals or the entire cavity of the lorica after feeding. Cytoplasm finely granular or densely packed with 5 to 20 micra diameter food vacuoles in recently fed speciments. Tenta-

cles arising from five equatorially equidistant, vertically elongate fascicles under each of the five orfices in the lorica and reaching a length as great as five times the diameter of the lorica and a number as great as 60. Massive single macronucleus, either spherical (average diameter 10.7 micra) or elliptical (average dimensions, 12.2 by 8.1 micra), central. Spherical contractile vacuole (8 to 12 micra in diameter), near macronucleus. Single micronucleus spherical (average diameter 2.3 micra), invisible in live specimens. Lorica diameter, 44.1 micra (23 to 62 micra). Body diameter, 27.1 micra (15 to 50 micra). Lorica height, 41.4 micra (17.5 to 53 micra). Reproduction by internal budding. Bud with monaxone symmetry, oval, bearing no tentacles, cilia in 8 to 10 oblique rings around the body surface and comparable infraciliary pattern, single micro- and macronucleus, single contractile vacuole, finely granular cytoplasm. Dimensions 26.7 micra long by 13.6 micra diameter (14 micra long by 7.3 micra diameter to 33 micra long by 27 micra diameter). Habitat: fresh water.

The criteria for detrmining the taxonomic status of species of Suctoria were considered in the light of recently proposed modifications in the taxonomy of Suctoria. These modifications, advocated by certain European workers, are based upon phylogenetic evidences resulting from the infraciliary patterns of the migratory buds of the various species of Suctoria. These infraciliary patterns have been determined for only a comparatively few species of Suctoria and they have not yet been correlated with the adult morphology of the suctorians from which the buds are derived. Therefore, it is considered premature to attempt any sweeping revision of the taxonomy of Suctoria on the single basis of these evidences. The more widely accepted and used criteria for the taxonomy of the group were considered and their utility demonstrated in the identification of **S. micraster** and **Discophrya collini.** These criteria, in order of their importance, are 1) adult

morphology 2) bud morphology and 3) type of budding.

The life cycle of **S. micraster** involves the formation of a free-swimming bud by an adult usually within 2 hours after this adult has completed feeding on a living ciliate. The first indication of bud formation is the elongation of the single spherical or ovoid macronucleus which is difficult to see in life due to the abundance of food vacuoles. Therefore, observations were based upon stained specimens. Early in the elongation of the macronucleus, division of the single spherical micronucleus is accomplished. By the time the macronucleus has reached the stage when it assumes a bilobed shape, the external surface of the protoplasmic body shows a circular indention which deepens as the elongation of the macronucleus progresses. Deepening of the surface indentation continues until the ovoid body of the future free-swimming bud is cut off from the parent cytoplasm. Then the bud is completely separated from the adult and starts to move slowly in the brood cavity, eventually escaping by spreading one or more of the apical sutures in the adult lorica. During the formation of the bud, cilia appear on its surface shortly after micronuclear division is accomplished and the liberated bud swims actively through the culture medium for varying periods of time by means of these well coordinated cilia. The formation of the bud is a comparatively rapid process, usually requiring not longer than 40 minutes from the first appearance of the surface indentation until the completed bud is free in the surrounding medium.

After a period of free existence, varying between one minute and 24 hours, the bud chooses an acceptable solid substrate to which it fastens and metamorphoses into the typical adult form. This process of metamorphosis is likewise rather rapid, seldom requiring more than 30 minutes from the time the bud attaches until it shows the typical pentagonal outline of the lorica and has three or more functional tentacles projecting from each angle of the pentagonal lorica. Assumption of the typical spherical

protoplasmic body outline may be delayed several hours, but always by the 24 hour stage, the protoplasmic body assumes the contours of a sphere filling approximately two-thirds of the lorica cavity.

Feeding habits of **S. micraster** were examined in regard to the selection of ciliate organisms acceptable as food. It was determined that **Spirostomum** spp., **Didinium** sp., **Blepharisma** sp., **Stentor** sp., **Halteria** sp., **Tetrahymena gelei** (strain W), **Loxodes** sp., and **Paramecium** sp. are acceptable as food as indicated by the adherence of tentacles to the pellicle of these ciliates. However, the larger organisms and those capable of sudden powerful contractions were often able to escape the hold of the Suctoria by breaking the tentacles, although almost never were the tentacles observed to lose their hold on the ciliate pellicle. Smaller ciliates (**Halteria, Tetrahymena**) were unable to escape from the hold of even a single tentacle. Further, the Suctoria often captured and fed upon as many as eleven of these smaller ciliates at the same time, **Stylonichia** sp., **Eupotes** sp. and **Coleps** sp. were never observed to adhere to the tentacles. This was considered to be due to differences in pellicle structure of these "armored" ciliates from that of the acceptable species.

Specimens of **S. micraster** were subjected to various physiological stresses such as high and low pH, overcrowding in the culture containers and exposure to excessive organic debris in the culture medium, in order to determine if these physiological stress situations would produce morphological variations in the adults or buds. The stresses selected were chosen in an attempt to duplicate to some degree the stresses extant in the "terrestial" environments from which Penard obtained specimens upon which he based new species descriptions. These environments were invariably periodically desiccated mosses growing upon tree trunks or old walls. The morphological variants of **S. micraster** obtained by the experimental means were taken as indication that the rigorous conditions from which Penard obtained his specimens

could be expected to produce a wide variety of morphological variants in the included Suctoria and therefore, some of the species described by Penard were considered questionable until they can be reexamined and the physiological conditions of the source environment evaluated.

The change in rate of contraction of the contractile vacuole of **S. micraster** was measured during the processes of feeding and subsequent reproduction. This cyclic rate change was correlated to previous reports on similar changes in vacuolar rate in other species of Suctoria. The functional implications of the consistent rate cycle so determined was also considered. This vacuolar rate cycle follows a regular chronological pattern which may be summarized as follows:

1. Rapid increase in rate to approx. 4-5x non-feeding rate upon contact of the tentacles and food organisms.

2. Rapid decrease to approx. 2-3x non-feeding rate upon release of the food organism from the tentacles.

3. Rapid increase in rate to approx. 3-4x non-feeding rate as soon as reproduction commences, as indicated by the appearance of the circular indentation in the protoplasmic body surface.

4. Rapid decrease in rate to approx. 2x non-feeding rate as soon as the bud is formed and its contractile vacuole initiates activity.

5. Gradual decrease in rate to approx. non-feeding rate upon release of the bud and its escape from the parent lorica.

The absolute time intervals between any of the above events varied depending upon the number of tentacles involved in the feeding process, the comparative sizes of the suctorian and prey animal, and the size relations of the adult and developing bud.

Collections were made from permanent and temporary ponds

and streams in the vicinity of Champaign-Urbana, Illinois. One species of Suctoria from a collection made in a drainage ditch on University of Illinois grounds was established in clone culture. Its adult and bud morphology established it as **Discophrya collini** (Root) 1915 and the synonymy of this name to **Discophrya piriformis** Guilcher 1947 was established. Other Suctoria observed included the following forms: **Dendrocometes paradoxus, Tokophrya** spp., **Periacineta** sp., and **Acineta** spp. Identification of the species observed from the field collections was not made below the level of genus, unless the three criteria for species identification in Suctoria as indicated previously were observed.

Upon consideration of the available literature, in addition to the detailed observations on **S. micraster,** it was proposed that the following species of **Solenophrya** be considered valid: **S. crassa** Claparede and Lachmann, **S. notonectae** Claparede and Lachmann, **S. inclusa** Stokes, **S. pera** Stokes, **S. oblonga** Stokes, **S. alata** Stokes, **S. polypoides** von Daday, and **S. micraster** Penard. The following species of **Solenophrya** were considered of questionable validity on the basis of the morphological variants of **S. micraster** produced experimentally, since many of these variants resembled the descriptions given by Penard for these species: **S. sacculus** Penard, **S. massula** Penard, **S. flavescens** Penard, **S. dubia** Penard, **S. bulbacea** Penard, and **S. calyciformis** Penard.

VITA

Robert William Hull was born April 3, 1924, in LaCrosse, Indiana. He attended elementary school at Morton, Illinois and graduated from Morton Township High School in 1942. In the fall of 1942, he entered the University of Kansas, Lawrence Kansas, and there completed accelerated course in electronics supervised by the Army Air Force. He entered the Army Air Force in July, 1943 and served at the Aircraft Radio and Radar Laboratory, Wright Field, Dayton, Ohio until his honorable discharge in February, 1946. In March, 1946, he enrolled in the University of Illinois and received the degree of Bachelor of Science from that institution in June, 1949. He began his graduate work at that time and received the degree of Master of Science in 1950 from the same institution. During the summer of 1951, he completed the Invertebrate Zoology course at the Marine Biological Laboratory, Woods Hole, Massachusetts. From September, 1951 to June, 1953, he acted as one-half time research assistant to Professor R. R. Kudo, Department of Zoology, University of Illinois.

He was elected in 1951 to active membership in Phi Sigma and associate membership in Sigma Xi and served as president of Rho Chapter of Phi Sigma during the academic year 1952-53. He is also a member of the Society of Protozoologists, American Microscopical Society, Society of Systematic Zoology and American Association for the Advancement of Science.